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INSTITUTE OF
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# PREVIEW

AMONG the varied activities of the United States Government none is of more interest to the engineer than the work of the Bureau of Standards. In this issue we present a survey of the work accomplished by this organization during the past year, written by its director, Dr. George K. Burgess. The reader will no doubt remember that the late Samuel W. Stratton, former president of Technology, was for some years director of the Bureau, and did much to establish it as the leading non-commercial research organization in America.

THE problem which the engineer faces in his dealings with industry is discussed by Mr. Samuel Lewisohn of New York, son of the famous Adolph Lewisohn of that city. In his many dealings with engineering enterprise, Mr. Lewisohn has gained valuable experience in the field of industrial relations, and is, therefore, well equipped to advise the student engineer. His discussion of the labor problem is of particular value.

MODERNISM in Architecture may appear to be a subject fit for discussion only by experts, and then only in a highly controversial manner. But, inasmuch as architecture is planned for the public, the reactions of the layman to the modern tendencies should be illuminating to everyone concerned. Mr. Edmund Lucas, a sophomore in the Department of Physics, is, avowedly, a layman; in his article he tries to show how the modern buildings differ from those of the past, and why the changes have come about.

THE final installment of the series by Prof. Frederick K. Morris marks the close of the story of the coming of life to the earth. In this article, Professor Morris describes the evolution, from dead substance, of the biomolecule. This molecule, the basis of the first living creature, is the final step on the path from the sun to the beginning of life on the earth. Little need be said at this juncture of the charm and penetration of Professor Morris's style. This presentation of scientific theory is, we believe, outstanding in its appeal to every type of reader.

TWO articles, whose subjects are closely related, present the findings of the vanguard of physics. The first, by Prof. W. B. Nottingham of the Department of Physics, describes the field of electronics, and its relation to engineering. This article contains, among other things, a most clear and concise discussion of the present concepts of the electron and the atom. The vortex atom, a new picture, is fully discussed. The second, by Prof. R. D. Bennett, of the Electrical Engineering Department, describes the projected world-wide investigations of the cosmic ray which will take place this spring. Professor Bennett, as leader of the Alaskan expedition, is eminently fitted to describe the aims of the work.


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*Aquatint etching of New Waldorf Astoria Hotel, N. Y.*

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# The TECH ENGINEERING NEWS

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# THE TECH ENGINEERING NEWS

THE PROFESSIONAL JOURNAL OF THE UNDERGRADUATES OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME XIII — MAY, 1932 — NUMBER 4


# *Engineering at* THE U. S. BUREAU OF STANDARDS *—a Survey*


*By* ***GEORGE K. BURGESS***
***Director, Bureau of Standards***
***Washington, D. C.***


FROM previous articles in THE TECH ENGINEERING NEWS, many of its readers are familiar with the fact that the Bureau of Standards is the principal testing laboratory of the Federal Government. The Government is the largest single purchaser of supplies in the United States, and as many of these purchases are controlled by tests at the Bureau, every variety of work is represented. Samples range all the way from clinical thermometers to Portland cement.

During the past year the Government has carried on an extensive building program, not only in Washington but in many other cities. This has been reflected in an unprecedented increase in tests of building materials. The volume of cement sampled reached 2,311,000 barrels, the highest on record, and 42 per cent above the figures for 1930. These tests were conducted in the Washington laboratory and also in the Bureau's branch laboratories at Northampton, Pa., Denver, and San Francisco. The equipment at Denver has been augmented by the installation of a 4,000,000 pound precision hydraulic machine for compression testing, and some equipment for general work on textiles, rubber, and leather has been added in the San Francisco branch. The Bureau is, therefore, reasonably well equipped to care for the test work of the Federal Government outside of Washington. With the growing use of specifications in Federal purchasing, the importance of these branch laboratories will increase.

A series of tests has been in progress for about a year on the fire resistance of interior partitions, including partitions of magnesite-wood fiber blocks, treated wood, and wood supports faced with gypsum plaster on plaster board. In coöperation with the American Institute of Steel Construction, equipment was installed for fire tests on welded steel floors. The furnace is so arranged that fire can be applied above as well as below the floor panels, which are 13½ by 18 feet in size. Any desired load can be applied and deflections measured. These tests are under way at the present time.

Another important investigation, in connection with building materials, which has just been completed,

covers slate for roofs and similar purposes. Tests were made on 350 samples of new and weathered slate from all the important producing districts in the United States. A test procedure for determining weathering characteristics was developed, and the results of the work are serving as a guide in the preparation of a Federal specification.

The Bureau serves as the research and testing division of the Aeronautics Branch of the Department of Commerce. The work includes the testing of aircraft materials, development of aids to air navigation, and type testing of airplane engines. During the year a new pointer type of indicator was developed, for use in connection with radio beacons, which shows the pilot whether he is on or off the course. This is an improvement over the original reed indicator in which the ends of the two vibrating reeds were viewed as parallel white lines of varying lengths. A special receiving set for simultaneous reception of telephone messages and beacon signals was also developed. The shielding of the ignition system of the engine to prevent interference with radio signals is still a difficult problem, but mainly one of expense, since it is possible to eliminate interference by the use of a proper "harness" over the magnetos, wires, and spark plugs. Radio equipment which will permit the blind landing of aircraft in fog is also being developed, and parts of the complete equipment have been found to function very satisfactorily.

During the year ended June 30 last, 27 new commercial airplane engines were tested for the Aeronautics Branch. These included 11 radial engines (among them, one Diesel), 8 inverted in-line, 4 horizontal-opposed, and 4 V-type, including a 12-cylinder inverted V. Of these engines, 14 passed the test, 11 failed, and 2 were withdrawn. Eight of the engines which failed were of new types, and 3 had received one previous test each.

In coöperation with the National Advisory Committee for Aeronautics a special cotton cloth was developed for making parachutes. This has passed military tests, and in an emergency can be substituted for silk.

For many years the Bureau has assisted the American motorist, through studies of engines, fuels, lubri-

cants, tires, brake linings, headlights, and car performance. Good progress has been made in the control of vapor lock — the boiling of fuel in the supply line or carburetor which results in stalling the engine with annoying and perhaps serious consequences. Use of proper fuel to suit weather conditions is part of the solution. The rest lies in better designed fuel systems in which overheating of the pipes can not take place. As the result of the Bureau's recommendations improvements are being incorporated in many of the 1932 cars.

An important addition to the Bureau's physical plant is the new National Hydraulic Laboratory. The building has just been completed and installation of the equipment is now in progress. The building is unique and presented many perplexing construction problems. However, the design was worked out with great care, so that when actual building operations were started they went forward smoothly and rapidly. The building is 285 feet long, with a width at the east end of 92 feet, the remainder being 60 feet wide. There are two large concrete supply basins from which water is pumped through flumes and other experimental apparatus to a concrete measuring basin, from which it may be returned to the supply basins. A maximum flow of 250 to 300 cubic feet per second will be possible in the main flume, which is the dominating piece of equipment, with a cross section 12 feet square over a length of approximately 200 feet. There are two large Venturi meters, one 8 feet, and the other 3 feet in diameter. The building has been designed with large unobstructed floor areas on which models can be built, and convenient water connections are everywhere available.

Many problems are already on the books of the new hydraulics section, and will be taken up as soon as sufficient equipment is installed. The laboratory will serve several branches of the Government, such as the Corps of Engineers of the United States Army, the Bureau of Reclamation and the Geological Survey of the Department of the Interior, and the Bureau of Public Roads of the Department of Agriculture. All these services are concerned with the design of hydraulic structures, and now, for the first time, laboratory facilities will be available for the solution of their problems.

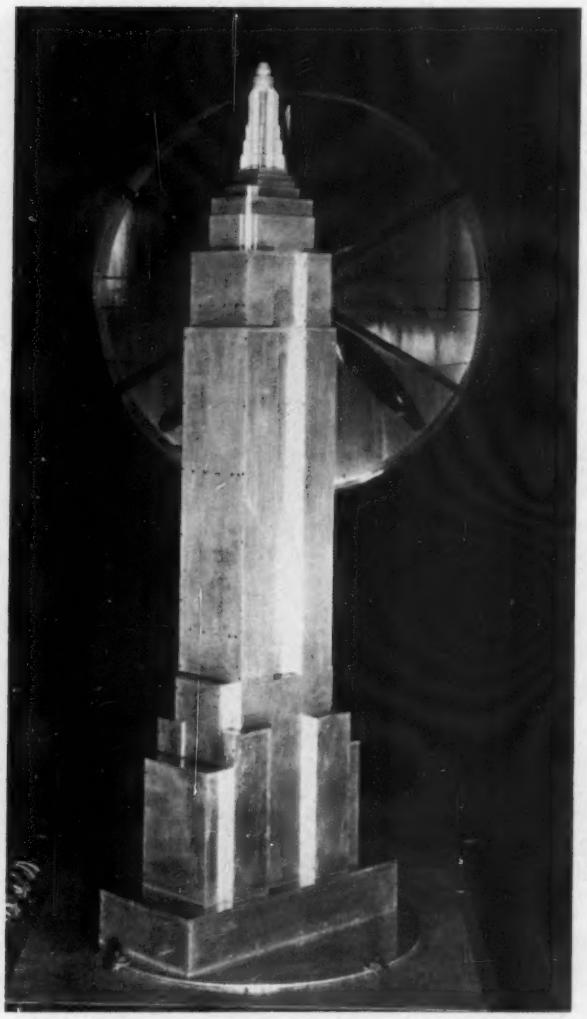
Another class of work in hydraulics involves measurements of capacity flow in sloping drains up to 6 inches in diameter. The carrying capacity of vertical pipes with side inlets, as in plumbing systems, is also being studied. To carry on this work a special tower, 100 feet high, has been constructed. This is surmounted by a tank with a capacity of 3,000 gallons, and there are pumps and supply pipes giving a flow of about 600 gallons per minute. Plumbing installations in a tall building can thus be duplicated and valuable data for the plumbing industry are being secured. These may result in some revisions of the recommendations contained in the Department of Commerce's "Recommended Minimum Requirements for Plumbing."

The National Screw Thread Commission, whose headquarters are at the Bureau of Standards, has been conducting a national survey to determine the extent to which the commission's screw thread standards are being accepted and followed by industry. The American Society of Mechanical Engineers is coöperating in this work, and over 7,000 samples of bolts and nuts have been collected from many industrial centers and are being measured at the Bureau. As a result of the work it may be found advisable to revise the fine or Class 4 fit to bring it more into line with actual conditions of manufacture and use.

The determination of the thermal properties of water and saturated steam is progressing very satisfactorily. Preliminary measurements have already been made at a pressure of 2,400 pounds per square inch and temperature of 350° C. Several papers have been published, including one in the March number of *Mechanical Engineering*.

The architect and builder have been assisted by wind tunnel studies on models of typical buildings, including the Empire State Building in New York. This model was constructed to a scale of one in 250, and pressure measurements were made at wind speeds up to 60 miles per hour in the Bureau's 10-foot tunnel. As some of your readers may know, connections for pressure-measuring instruments have been built into the actual structure at the thirty-sixth, fifty-fifth, and seventy-fifth floor levels. The research committee of the American Institute of Steel Construction plans to carry out a program of measurements on the building and when these are completed, a comparison will be possible between results on the building, itself, and on the model. The Bureau believes that these will bring out the value of wind tunnel tests on buildings, as well as on aircraft.

Taken as a whole, the year at the Bureau has been a far more satisfactory one than might have been expected, and has resulted in many important contributions to the data available to the engineering profession.



***A new use for the wind tunnel: A model of the Empire State Building is the subject of pressure studies at the Bureau of Standards. Wind speeds as high as sixty miles per hour are attained.***

# *Labor Offers*

# THE ENGINEERING EXECUTIVE

## *a Hard Task*

*By SAMUEL LEWISOHN*

***Part I: The Industrial Relation of Brain to Brawn***

COMING into Grand Central Station one morning I noticed on the tracks a gang of workers, and standing beside them a young engineer supervising their work. It symbolized for me the problem which I wish to discuss — the contact between brains and brawn — the engineer and labor.

There is the popular view that the only problem the worker is interested in is wages and that there is nothing else to the labor problem. The fact is, of course, that wages are not the sole influence that makes workmen give effective results. We see again and again examples of two factories existing side by side in the same vicinity, paying exactly the same wages, one of which has a contented, happy working force, and the other of which has a dissatisfied, restless group of employees. Here we have, in a rough way, the type of controlled experiment to which you are accustomed. In each case when we look for the factor that causes these different results we find it is the difference in method by which the administrative problems are handled in the aforementioned factories. We are apt to find in the one case the problem of employee relations was handled skillfully; in the other awkwardly.

I am not speaking entirely about imaginary cases, but to a large extent from experience. In plants under my own control there have been successive managers who secured quite different results in the spirit prevailing in the factory and, thus in the productive results. In each case the diversity in the productive results was due to the unequal degrees of thoroughness and skill with which the respective managers went about attacking their personnel problems.

The fact is that most people take it for granted that the labor problem is solely an economic problem when, of course, it is to a large extent an administrative problem. You have such a problem not only in industrial organization, but you have practically similar administrative problems in such organizations as the Red Cross organization, in the Post Office, or in a consumers' coöperative movement, in a college football team, in none of which there is any problem of capital and labor involved. The wage bargain only occurs once a year or at the most a few times a year. The rest of the time (in matters having to do with labor relations) is taken up with the administrative problem of getting the workmen to work together effectively.

The man who probably has the greatest influence in producing these administrative results today is the resident or local manager who is in charge of production problems and thus in charge of the organization of all his people. He is very often an engineer.

Dean Dexter S. Kimball of Cornell University described a situation which arose in connection with an opening of a managerial nature in a highly specialized engineering field. Those responsible for filling this managerial position had in mind a young engineer who possessed the technical knowledge involved. After a very thorough discussion the decision was reached not to give him the position because he showed no evidence of how to handle human beings generally. Naturally this was a serious disappointment to the young man, yet the more attractive positions open to engineers are almost in every case managerial. Indeed one hears complaints among young engineers of how limited are the opportunities in research work or staff positions as compared to the opportunities as managing executives and it is well to bear in mind that practically all such positions, particularly today, involve the organization of human beings.

It is well to recognize that there is an economic element which complicates administrative problems. But, as I have explained, in addition to these economic influences there are problems of a purely administrative nature, the solution of which is most important in producing a successful labor policy. In order to understand them, it may be well to outline the sort of thing that the worker desires. The attempt to fulfill these desires, as far as requirements of efficiency permit, will go a long way toward securing efficient administration. For the sake of having some framework I have roughly classified these desires into the desire for Justice, the desire for Status and the desire for Opportunity. I have just outlined the economic elements which directly and indirectly influence the feeling of the worker that justice has been meted out to him. I have explained how to only a small degree are these economic influences within the control of the employer and how to a larger degree they are controlled by forces outside the factory. But

(*Continued on page 78*)

*Technology Review*

# *The meaning of*

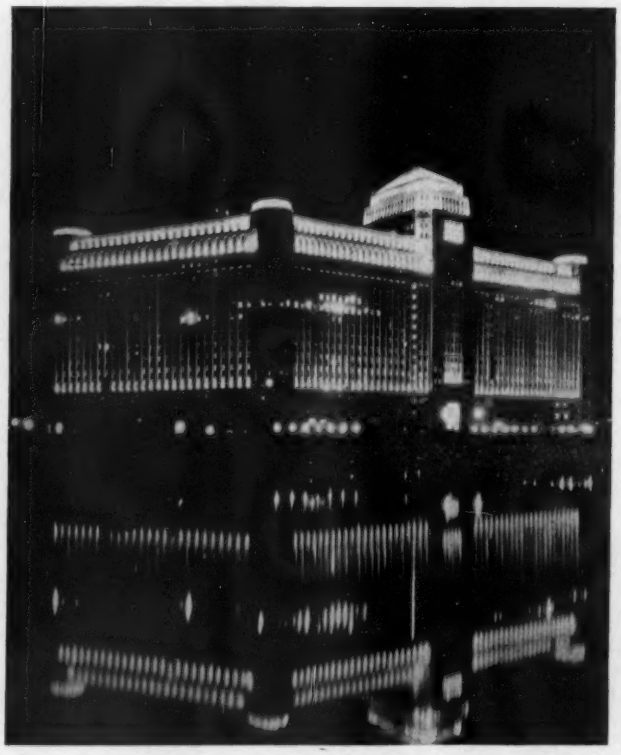
# MODERNISM IN ARCHITECTURE

## *—a Layman's View*

*By* ***EDMUND DELONG LUCAS, JR. '34***

DURING the past two centuries architecture, like society, has been in the process of transition. Every builder has been impelled by the urge to create Beauty; and the world is full of discord, a jumble of buildings, some exquisite, some passable, and not a few abominable. Out of chaos, however, is arising the New Tradition. With the over-adornment of the Rococo and the Baroque swept aside, the modern architects are working in new materials toward new forms.

The nineteenth century saw a bewilderment of taste. While a few architects, like Sir John Soane, builder of the Bank of England and the Soane Museum, were able to remain uninfluenced by the frenzy of exotic ornamentation, the majority had forgotten unity, coherence, and logic. The secret of coherent architecture is first, an adaptation of form to locality, and second, an intimate knowledge of contemporary society. For two centuries architects treated their art as a scholastic problem, "substituting archaeology for positive taste and pedantry for craftsmanship." William Morris' Red House, a distinguished English country home, is one delightful exception. Built about 1860, "it was free and comparatively organic in planning, distinctly picturesque in general composition." The designer, inventor of the Morris chair, was a socialist, poet, and Mediaevalist: he was also a practical man whose progressive ideas helped to foster the New Tradition.



*The Merchandise Mart, Chicago*

The dawn of the twentieth century brought an awakening. Dissatisfied by Victorian "gew-gaws," the designers of 1900 groped for a new expression. In England, as on the Continent, a new realization of Beauty was arising — the beauty of Simplicity. Architects who had worked in a vast medley of styles now left the bitter fruits of the nineteenth century behind. Plain surfaces, well-proportioned and logically placed, proved a relief to the eye once cloyed with ornamentation.

Modernism seeks indeed not merely to replace hackneyed styles and overworked stencils: artistic originality is spontaneous in response to new stimuli — the utilization of new materials, the adaptation of our surroundings to new modes and rates of living. The past is by no means discarded. In the words of W. Francklyn Paris, "Art syntax is based on truth and it is heresy to hold that because Pericles is dead we should no longer utilize Doric, Ionic, or Corinthian columns in our architecture."

The new school has accomplished marvelous changes in the way of exterior, interior and landscape architecture. The concern of this article lies chiefly with the exteriors of buildings in the modern form; and we shall deal with them from three points of view: First, the element of Symbolism as the modern treatment of Function in design; Second, the Individuality of new shapes; the Third, the practical purposes for which the new edifices are intended.

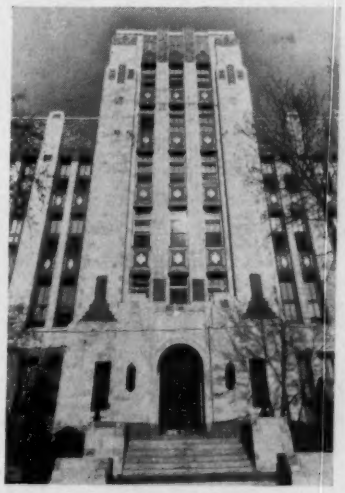
FOREIGN architects long since have discovered the value of symbolism. The Germans particularly, working in conjunction with their skilled technicians, have achieved striking results. The Chile House, in Hamburg, designed by F. Roger, shows the value of vertical lines. Standing on the neck of a V-intersection, the set-back forms of this building give it the effect striven for in many a modern skyscraper, the appearance of sweeping, graceful height, with an actual elevation of not more than one hundred feet. The Crematorium at Vienna, although influenced by the early Gothic forts, shows a distinctly modern treatment. The massive walls dominated by heavy buttresses, the narrow, arched windows, the clear-cut, simple curve of the tower all give the impression of the solemnity and awe of death. Saaririen, the great Finnish architect, built an excellent railway station at Helsingfors, Finland, before he revolutionized Detroit's building program. The railway station shows a detailed construction in the wings, plain curves and spandrels, topped by a symmetrical tower.

Perhaps the crowning piece of modern foreign symbolic representation is Einstein's observatory at Potsdam. The architect, Eric Mendelssohn, has designed the building along graceful stream-lines, thereby reducing the wind pressure and decreasing vibration. The building is white, with four windows like wide-open eyes to stare at the universe.

America's contribution is no less valuable and perhaps even more imposing. Raymond Hood, the great New York architect, a Tech man, incidentally, has accomplished several gigantic buildings. Thirty-six stories of tabloid newspapers: the long vertical sweep of columns in the Daily News Building broken by straight horizontal stages in irregular order has the grandeur of nudity. "A pile of coal glowing at the top" — such is Mr. Hood's own description of the stern battlements and set-backs of the American Radiator building when outlined at night in the glare of fiery searchlights. Most recent of all is the great pile of the McGraw-Hill Building. "Compared with the stark verticality of the Daily News Building, faire volte-face, the McGraw-Hill Building is nothing but horizontality and more. . . . The facades are merely superimposed layers of straight, perfectly plain spandrel walls and straight continuous rows of metal windows." The economy of design is remarkable, for every feature of the wall is at the same level. Outstanding are the tower, built of horizontal blocks intersecting at right angles to give the illusion of a giant's pile of magazines, laid crosswise each to each; and the ever-varying color of the building. The surface is green glazed terra cotta, blue under a summer sky, changing from gray to bright green with each day's sunrise or sunset.

In American domestic architecture, symbolism is not so sharply defined; but such sketches as that of Peter van der Meulen Smith for a seashore home in Massachusetts show the effect of unrelieved simplicity in line. The difficulty of austerity is overcome by the judicious use of landscaping.

INDIVIDUALITY of design is rife at present. Whether the originality of today will be extolled or condemned tomorrow we can not know. Suffice it to say that the architect has rebelled against academic restraint, from Andre Mare and Frank Lloyd Wright to Le Corbusier with his cry against Ornament. The building of today is geometrical. Beauty is in simplicity alone, exteriors of untrammelled silhouette, interiors resplendent in marvelous shades of metals. As Hood, modern of modern architects, says, "The building is designed to please the people inside, not those outside."

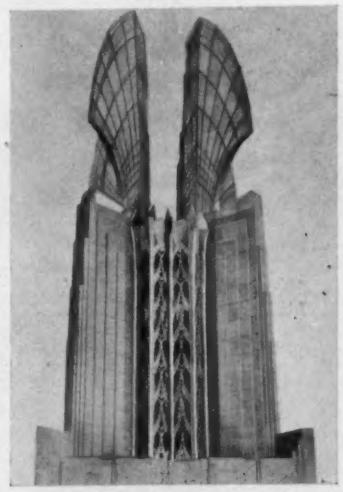


*A quasi-modern treatment; the present trend shuns all ornamentation but the simplest type.*

Of the interiors I can say no more than that the modern craftsman has the resources of a world at his command. Balsa from the Andes, guayatil from Panama, striped ebony from Gaboon, cocobolo from Nicaragua, flowerwood from China, koa from Hawaii, and longa tramena from Madagascar supply with the artistic tracery of their surfaces a beauty which needs no adornment in carving. Metal alloys, too, are silver gray, dark blue, olive green, or blood red. Artists have rediscovered the beauty of surprise. They captured the public eye in the instrument panels of the Empire State and the Chrysler Building, the maps, the naked, flat surfaces.

"Loveliness needs not the foreign aid of ornament
But is, when unadorned, adorned the most."

If illustration be needed, the long, bare white facade, reflected in Lake Geneva, of Le Corbusier's house at Vevey, or one of Mallet-Steven's houses in Paris, straight masses of white concrete, in irregular yet not unpleasing outline against the background of splendid trees and skilful gardens. J. J. P. Oud's shops in Hoek von Holland depend upon the sea for their background. The windows are large and vertical, the general construction rounded in low ramps, like "the low sea wall" beyond. Soap factories — among others — in the United States show the effective and original uses of simplicity. The Larkin Soap Factory Office Building, by Frank Lloyd Wright, like the proposed Palmolive Building in Chicago, is clustered in vertical towers with but little horizontal ornament. Another Chicago building, the Merchandise Mart, shown above, at night, reflected, combines the effect of height in the slim, vertical pillars with four massive corners and a squat tower.



*An extreme example of modernistic treatment; the spire of a bank building in Rochester.*

OF the practical purposes of the New Tradition books have been written. The modern industrial world demands utility; and architecture seems often reduced merely to the process of building shelters. Designers have, however, made tremendous improvement in the construction of buildings. Gone are the "flim-flam Flamboyant" or the elegant pseudo-ruins of the eighteenth century.

To dismiss engineering in a paragraph is abysmal but essential folly. The modern engineer differs from his predecessor chiefly in the greater strength and simplicity of his structures. Comparing for instance the Viaduct, Garabit, by Charles Eiffel with the George Washington Bridge by O. Ammann, we find that the earlier was splendid in form but contained a superabundance of light spars, while the modern bridge has heavier, fewer struts, saving in labor more than the value of the excess steel. Engineers of today are time-savers, too; the Pennsylvania Power and Light Building at Allentown, Pennsylvania, a recent skyscraper, took a mere sixteen months to build. Sir John Soane's Bank of England Building was the forty-five years, from 1788 to 1833, in construction.

For the present and the future architects are and will be guided most definitely by appropriate locations for particular styles of building. A skyscraper can dominate its neighbors but a modernistic country house in an exclusive suburb may look hideously out of place. City designers will find great scope for their originality in the proposals for increasing traffic space at the expense of lower floors. In Europe houses on stilts have been successfully attempted.

If the designers of tomorrow are to follow their modern predecessors in the New Tradition, we may safely say that simplicity will be the keynote.

*A Scientist Views*

# THE BEGINNINGS OF LIFE *on the Earth*

*By* ***FREDERICK K. MORRIS***
***Professor of Structural Geology***
***Massachusetts Institute of Technology***

***Part III: THE EVOLUTION OF THE CELL***

AS we open this third installment, we have almost crossed the great gap between the Sun and the Cell — between the flaming star from which we sprang and the cool, moist Earth with its living cells. Think of it, every atom in our living bodies once blazed in the Sun! We may or may not burn hereafter, but we have burned heretofore — and we didn't burn to a crisp, but to incandescence.

As surely as we were on a part of the hot Sun so surely were we a part of the cold Earth. We can understand how we cooled down — quickly, according to Chamberlin, slowly according to the hot-Earth advocates — but how did we become alive, we who once were atoms in crystalline rock?

For the first time in this discourse, we are going to look backward instead of forward and see what a vista we have down the immense perspective of the geologist's time scale. You have all glanced backward, perhaps with a smile, to the time when man's evolution was not so far advanced but that you would have called him a "greater ape" as Lord Tennyson did. The "missing link" is no longer missing, for we have fossils that give us a very fair idea both of what he was like and of when he lived. The time scale is all we need here; and, looking toward the brink, we find our eyes focussed on a point twenty million years back into the past. Even at that time the horse had hoofs and the elephant had a trunk, and the trees, the grass, and the flowers had much of their modern aspect. We glance farther along the converging perspective lines of time to where the horse was as big as a fox and had paws instead of hoofs and the ancestral elephant was a little pot-bellied herb-eater with teeth instead of tusks and an intelligent, wiggly nose instead of a trunk. Our eyes are focussed now upon a point fifty million years back in the time scale. The Rocky Mountains had not risen; and our school children would have thanked their stars that they knew as little geography as they actually know today; for the maps were so different then that with today's knowledge one couldn't have recognized any of the continents of that time. Yet at that distant time the warm-blooded hair-covered mammals dominated the world, the dinosaurs were extinct, the birds had long been flying, and the world had acquired its first true grasses.

We look more swiftly now along a deeper perspective through the great Age of Reptiles which was at least a hundred and twenty million years long. Yet at the early end of it, near two hundred million years ago, there were already good-sized dinosaurs and many of them had learned to walk upright on their hind feet like men or like kangaroos. There were no birds then — they were invented at a later date during the Age of Reptiles — but the mammals were already abundant and of many kinds. The "Age of Mammals" is a misnomer, for there were mammals throughout the whole of the Age of Reptiles. From this single fact we see that it has taken nearly two hundred million years to change a reptile into a man — and yet it is sometimes none too easy to see the difference.

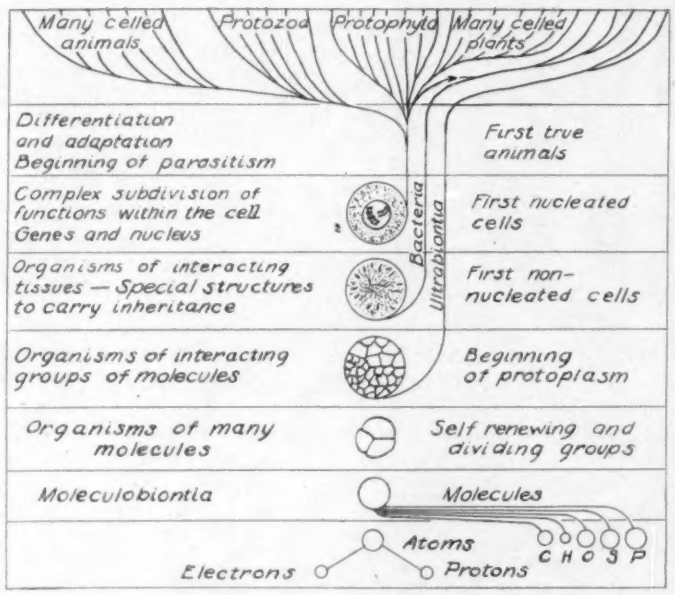



***Figure 1. This chart suggests the march of life upward toward the cell, but so small a chart cannot hint at the real complexity. Thus the cell should be drawn about 3,500,000,000,000 times the size of the electron; and for the measureless complexity of the cell, we refer you to Professor Wilson's books. The chart does show clearly that there was a very long evolution reaching from lifeless matter to the simplest cell, even if the chart errs in the stages of that evolution.***

Our next landmark would be the Coal Age during which the mammals first branched off from the reptiles, and the cockroaches attained their noblest proportions, for cockroaches nearly a foot long walked about the forests like dogs. They were strong enough to have jimmied our ice boxes, if we had had any then. Backward behind the Coal Age, our long perspective sweeps to a truly early time, fifteen hundred million years ago. The rocks which we now study are the oldest which the geologist ever sees. If he tries to look under them to see the still older rocks on which they rest, he finds instead that hot molten granite which has eaten its way up through the earth's crust and has wholly destroyed the oldest rocks. It is just as though we had a book containing a great epic story; but we can only begin to read it in the middle for the whole first half of the book has been torn out and burned.

What are the rocks like in that oldest period? What kind of an earth do they imply and what sort of life existed then, at the farthest point which our backward vista can reach along the geologist's time scale? Making allowances for all the heating and folding and squeezing and injecting of molten rock that has happened since

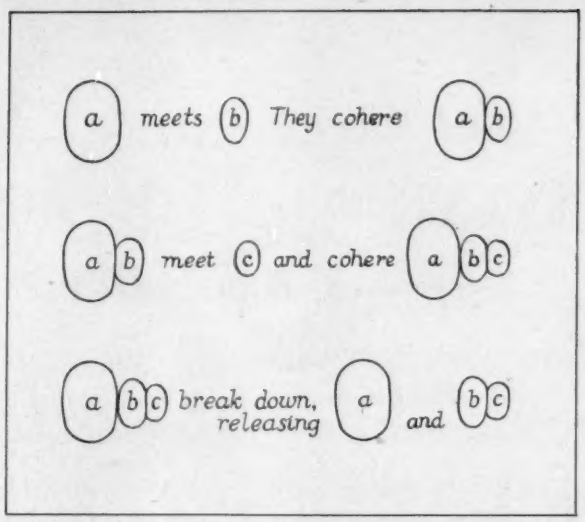



*Figure 2. The first atom, A, may act as a broker to bring about the partnership of two other atoms, B and C, which would not have joined without the help of A. This process is one of the first steps toward life from lifeless matter.*

those old rocks were laid down, we find them amazingly modern. There were vast beds of fine mud laid down in thin layers. Many of these beds were black with carbon where plants had been. There were masses of pebbles and boulders which many geologists believe were laid down by the ice of glaciers. There were vast beds of limestone which were undoubtedly the work of living creatures, just as beds of chalk and coral-rock and shell-rock are formed in the seas today by living creatures. There were flows of lava and beds of volcanic ash.

Thus we see that the earth at that time was very like the earth today. It had lands from which rivers washed mud and sand, and it had broad shallow seas that received the mud and sand and laid them out in orderly beds along with the limestone which living creatures made. There were occasional outbursts of volcanic eruptions such as we find today, and on no larger scale than the Age of Mammals has furnished. In short, the earth at that distant age was just as cool as it is today and had its lands and seas and winds and rains and ice as it has now. It was wholly habitable and it was richly inhabited. The seas teemed with life, and life had at least reached the dignity of the Cell. Many of us think it quite probable that the lands also were inhabited, by very simple plants. The story of life during the last fifteen hundred million years is merely the story of evolution — of change, of differentiation into new types.

Our backward vista along the geologists' time-perspective shows us that evolution is slow at all times; and that there's a great difference between the evolution of fundamental classes — mammals, reptiles, fishes — and the differentiation of a given class into diverse kinds of mammals or reptiles. Our backward look shows us, too, that in fifteen hundred million years we see no sign of the *beginning* of life — only the later chapters of its march upward from the Cell. The Cell itself is not only a beginning — it's a culmination; the triumphant achievement of an evolution probably as long as the entire evolution upward from the cell to the whale, the sequoia or the man. For the origin of life and for the march of life forward and upward to the complexity of a simple cell we must look back beyond those destroying granites into that long chapter of the earth's history which the granites have burned out.

### What is Life?

In this part of our story we have no rocks nor fossils to guide us and must rely upon hints which students of biology and chemistry give us. Here we step out of interpretative science and into speculation. This is dangerous ground but we shall not lose our way if we are careful not to mistake speculation for science — not to mistake what is claimed or guessed or constructively imagined as a working hypothesis for what is known by observation, inference, and experiment.

Life is not a thing, but a process. And, indeed, we are not concerned with life at all, but with the process of living. When we examine the simplest cell we find that it is full of complex processes. We are certain that in ultimate analysis these processes are chemical and physical, but they are so enormously complex (and take place within so small a space) and the reacting substances so translucent that we have not yet the means of scrutinizing the whole group of processes closely enough to describe the chemistry and physics of life accurately. We already know much, and are on the trail of more; and here our scientific builders are at work making solid land in one of the most abysmal depths of our sea of ignorance.

Can we define *living* with a definition that will fit our present knowledge, with the hope that the definition will not be found inconsistent with that future knowledge which we see coming? The simplest definition we can give is about as follows: matter which forms a sequence of chemical unions in such a way that it renews itself is living matter.

To illustrate: in Figure 2, let atom A meet atom B and unite, forming a compound AB. Let this compound now meet atom C with which B could not unite before

(*Continued on page 80*)

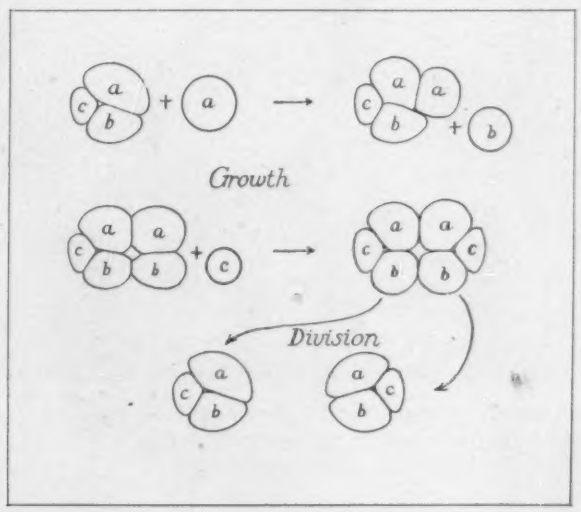



*Figure 3. The group of particles, A B C, unites chemically with other individual particles A, B, and C, until the group is doubled. It can now break down into two identical groups of A B C. In such a reaction, the barrier between lifeless and living matter is passed. The contrast between the living and the lifeless is striking only when we compare very complex organisms like the cell with mineral matter.*

Technology Review

*The mural in Walker Memorial which symbolizes the leadership of knowledge, the work of Edwin H. Blashfield '69.*

# *Present Day* ELECTRONIC THEORY *—a Brief Review*

*By WAYNE B. NOTTINGHAM*
*Professor of Physics*
*Massachusetts Institute of Technology*

THE "electronics" branch of the general field of physics deals mainly with problems of electrical conduction in metals, the emission of electrons from metals by heat and light, and electrical conduction in gases. Each of these divisions constitutes an important field of fundamental investigation broad enough to attract many research workers and the results of their studies are increasingly important to the modern engineer.

### Electrons in Atoms

Atoms are known to contain both positive and negative electricity. All of the positive and about half of the negative electricity is concentrated in a very small region known as the *nucleus*. The "units" of negative electricity are called *electrons* and the positive unit is known as the *proton*. Although the amount of charge carried by a proton is *equal in magnitude* but opposite in sign to that of an electron, the *mass* of a proton is 1845 times that of an electron. Thus, with *all* of the protons and half of the electrons *concentrated* together, we recognize this nucleus as a massive positively charged core which forms the center of an atom. In the neighborhood of each nucleus electrons are found. Normally, there are just enough of them exactly to neutralize the positive charge of the nucleus. According to certain theories, the electrons form a minute planetary system in which they revolve about the nucleus here playing the rôle of the "sun."

There is another "atom and model" which is very useful for the discussion of problems in electronics. This might be called the "potential field" model. According to this way of looking at an atom we simply concentrate our attention on the fact that *work must be done* if we separate one of the negatively charged electrons from the positively charged nucleus. We can picture the situation very crudely by imagining that the nucleus creates a sort of "vortex" in the potential field which extends throughout all space. Above the line over the top of the "vortex" an electron moves freely and is outside the atom. *Below* the vortex line there are many possible positions for electrons but not all locations are *permitted*. In other words there are certain discrete energy levels down in the "vortex" with all of the lower ones occupied when the atom is in the "normal state." If we give an electron in an occupied level sufficient energy to lift it up to one of the "unoccupied" levels and then observe the atom at the time the electron falls back into its original level, we discover that the energy which we put in now comes back to us as *radiation*, that is, a *light quantum* is

*(Continued on page 78)*

# *Prospecting for* THE COSMIC RAY *—a World Survey*

*By* ***RALPH D. BENNETT***
***Professor of Electrical Engineering***
***Massachusetts Institute of Technology***

**EDITOR'S NOTE. To Professor Bennett goes the honor of being the leader of one of six expeditions which are to be undertaken this year for the purpose of assembling information about the much heralded cosmic ray. Professor Bennett leaves this month for the Sierras, the Rockies, and the mountains of Alaska where, with the coöperation of Professor J. L. Dunham of Harvard, he will investigate the characteristics of cosmic radiation.**

THE Carnegie Institution of Washington is supporting this summer under the direction of Prof. Arthur Compton of the University of Chicago a world-wide cosmic ray survey, in the hope of throwing further light on the source, nature, and origin of this most interesting radiation.

One of the most obvious manifestations of any sort of penetrating radiation is its ability to make a gas electrically conducting. Coulomb nearly a century and a half ago noticed the conductivity of the atmosphere, but it was not until the discovery of radio activity by Becquerel that the cause was even partially explained. The radio active substances in the earth and air, though minute in quantity, are sufficient to account for most but not all of this conductivity.

A group of Canadian physicists undertook about thirty-five years ago to shield an electroscope from these radio active radiations by surrounding it with large masses of absorbing substances. They found that the electric leakage through the air in the electroscope was greatly reduced, but not entirely removed, by such shielding. The slight residual conductivity they attributed to some more penetrating radiation of unknown origin.

In the years immediately preceding the war a group of German scientists, took up the study of the penetrating radiation. They made a number of balloon flights measuring the residual conductivity of a mass of gas at different heights above the earth's surface. Their observations showed that the effect in general increased with altitude, and pointed to a source somewhere external to the earth.

The era of refined measurements of cosmic radiation began a few years after the war. With the help of improved apparatus better measurements have been made at many altitudes and many points on the surface of the earth. These measurements have established certain facts, namely: that the radiation is vastly more penetrating than any which can be produced in the

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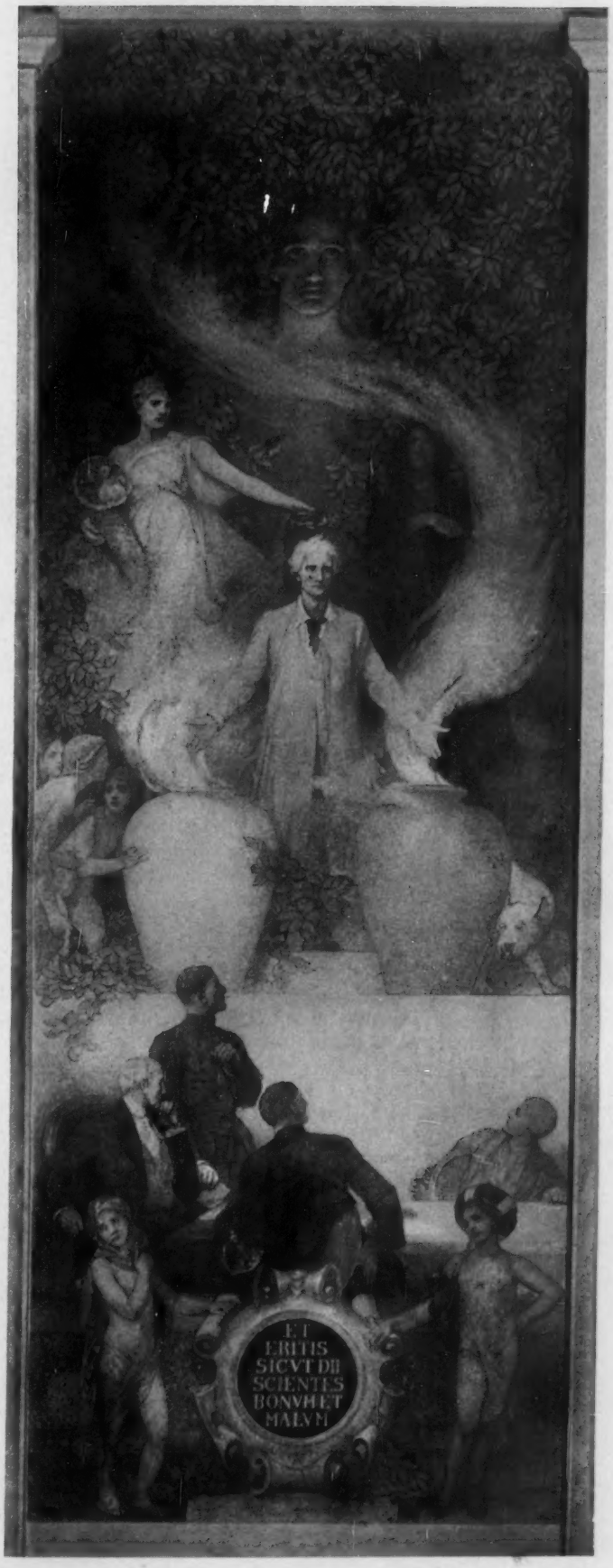


***". . . . And you shall be as gods, knowing good and evil." The mural by Blashfield in Walker Memorial.***

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# EDITORIALS

### The Honors Idea

An alumnus of the "Tech on Boylston Street" would probably, if landed unawares on our campus from the magic carpet which annihilates time as well as space, be aghast at the revolutionary and, we hope, evolutionary changes evident. There is no doubt of it. The refining influence of time is tending gradually to transform the Institute into a university. The new schools into which students are arranged, are a sign of the times.

One of the outstanding advances, appreciated but little by many undergraduates, is the Honors Idea.

The chief objection to education in an engineering school has arisen from one of its greatest virtues. The engineering education "has been free from the stigma of a four-year loaf," to quote Prof. R. H. Frazier of the Institute; but "there was insufficient stimulation" for a student's originality and imagination. The tendency, according to leading executives, was thus to develop proficient followers rather than forceful leaders.

Dean Seashore of Iowa State University was responsible for the first steps in classifying undergraduates in engineering schools, recognizing that the rate of learning is most decidedly a variable quantity. Honors work, long the recognized prerogative of liberal arts colleges, from Oxford and Cambridge with their tutors to the house system at Harvard and the preceptors at Princeton, is now extending from the pure sciences to such subjects as electrical engineering. Attendance for upperclassmen in such honors courses is entirely optional. Features of the work include wide freedom of choice in problem study, unbounded opportunity for original work, required attendance only at tests and examinations, except in the final term of the senior year when a comprehensive examination is presented to the candidate for a degree. For this "comprehensive" a student has ample time, complete liberty to use such references and texts as may be available; the principle is to encourage fertility in solving problems rather than the hasty "cramming" of facts for an examination.

The virtues of such a system are self-evident. If a student possesses the mental calibre requisite for success in college as well as in further work, his creative ability should not be atrophied by disuse. Here, surely, is the chance both for the student himself as well as for the prospective employer to size up the man in terms of performance, not as a well-oiled, carefully supervised machine, but as an original, earnest human being.

### Albert Einstein Believes

Life for Herr Einstein is something far too vast for mere human beings to comprehend, yet he himself has tried to solve the riddle in his own way. Loathing the comfort-loving and happiness-seeking philosophy of the "herd," he has substituted those ideals which fill him with the joy of living: goodness, beauty, and truth. An unassuming life devoted to intellectual pursuits is far superior to the materialistic ambitions of ordinary mortals.

He is keenly interested in social problems yet finds that he prefers solitude. Even although he suffers from this isolation he profits by it in freedom from the opinions and prejudices of others.

Democracy is his ideal of the civil state, because where despots reign by force there moral inferiors gather. Consequently he despises the "odious militia." Not man, but an automatom, is needed for such contemptible tasks. "War is low and despicable" and is the result of the corruption of the common sense of the people by the "school and press for business and political reasons." We might pause to note that Bertrand Russell found that people who did not have to go to war actually enjoyed it — that there was almost an inborn instinct to fight.

He is troubled because he must lean heavily on the works of a great number of the living and the dead.

As religious men stand in awe of the mysterious, so is he himself religious; but here the likeness ends. Only those who wish to be deceived would believe in a God who punishes the objects of His creation — "who is but a reflection of human frailty." That the body can survive after death is to him unbelievable. For him "it is enough to contemplate the mystery of conscious life perpetuating itself through all eternity, to reflect upon the marvelous structure of the universe which we can so dimly perceive, and try humbly to comprehend even an infinitesimal part of the intelligence manifested in nature."

*Sibley Journal of Engineering*

***A model of the Empire State Building struck by artificial lightning, a startling example of modern laboratory technique***

### Flicker of a Flame

Professor Morris's series of articles in the TECH ENGINEERING NEWS points out an obvious truth, not often remarked. Thirteen hundred million years ago the earth was covered with forests, lakes, rivers, deserts. Fifty thousand years ago a high-powered telescope on the moon would have discovered no changes.

Then came man. Remorselessly, ceaselessly, he toiled to alter the face of the earth. He covered it with cities and denuded it of trees. He bent the vagaries and fantasies of Nature to suit his own purposes. He dwarfed distance and made light of time. If he has not yet made the mountain come to him, he has at least given himself the means of going to the mountain quickly and comfortably.

In a few short moments, relatively no more than the flicker of a candle flame, man has done what thirteen hundred million years could not effect. If the next fifty thousand years are as fruitful in progress, the results will be far beyond the compass of our imagination; but social advance, moral advance and political advance should be our aim. Man's knowledge may have reached a peak on the upward road, but his social standards have shown no distinctive improvement. Let us, therefore, be eternally dissatisfied, on our guard against complacency, and press on toward the goal of intelligence, justice and peace.

### Depressed Politics

If the current depression has taught us anything, it should be the virtue of forethought. We can scorn "the rugged Russian bear," but the accurate planning for the future which has been typical of Stalin's regime demands our attention as the civilized world staggers under a weight of poverty and graft.

"The degree of civilization of any people is measured by the degree to which they plan their current activities for the sake of reaching a future goal," said Dr. Karl T. Compton in his recent address at the Academy of Political and Social Sciences in Philadelphia. He continued with a discussion of several bills now before state and national legislatures. The purpose of these measures is the budgeting of public enterprises on a five-year basis. The budgeting is voted one year in advance but actually provides for one-fifth of the whole program each year. For further stabilization, construction could be speeded up by six months whenever unemployment became acute. Such businesslike proposals should appeal to the common sense and thrift of the populace; unfortunately, only too often the political interest of the average citizen, the Babbitt of today, is restricted to gangster killings and to a mild upheaval every four Novembers.

It may be all very well to sigh gently, "They're only human," when prosperity lines politicians' pockets with gold. But when "To Let" signs appear like mushrooms on either side of Fifth Avenue, the pinch at our pocketbooks should arouse us to far more than a mild interest in civic affairs.

### The Spring Elections

The Managing Board of Volume XIII takes pleasure in announcing the following elections and promotions: Gordon K. Burns '34 to the position of Associate Managing Editor, Frank H. Moore '34 to Contributing Editor, William R. Haseltine '34 to Contributing Editor, Howard E. Bernhardt '35 to Features Editor, Henry J. Ogorzaly '35 to Assistant Editor, Charles S. Sutton '35 to Assistant Editor, Frank J. Messman '35 to Assistant Managing Editor, C. Warren Bubier '35 to News Editor, Cecil E. Mann '35 to Assistant Publicity Manager, G. Donald Fenton '35 to Assistant Advertising Manager, Alfred R. Johnson '35 to Assistant Advertising Manager, Kenneth D. Finlayson '35 to Assistant Treasurer, Albert B. Parks '35 to Assistant Treasurer, Henry B. Kimball '35 to Assistant Circulation Manager, Arthur W. Gilbart, Jr. '35 to Assistant Circulation Manager.

# ENGINEERING DIGEST

*Condensations of outstanding articles in the trade and scientific journals, published by special permission*

## The New Ford Air Liner

*Condensed from* Aero Digest, *April, 1932*

Accommodations for forty passengers — 110-foot wing spread — engines totalling over 2500 horsepower — these figures give some idea of the size of the new Ford all-metal cantilever type monoplane. The ship, intended for de luxe transportation on long-distance flights, has all the modern conveniences associated with travel, including sleeping accommodations similar to lower berth Pullmans. Other unique features of this mammoth liner are a smoking room; a steward's galley provided with a gas stove, refrigerator, running water, and other conveniences; and a main cabin, 8 by 41 feet, thermostatically heated and ventilated. Even a drinking fountain has been provided for the comfort of the passengers.

The plane is duo-controlled, the pilots sitting in the nose of the ship with full vision on all sides. Vision behind and above is provided by means of mirrors. The wings have a spread of 110 feet, with a maximum chord of 20 feet 10 inches and a maximum depth of 4 feet 3 inches. A new advance in design is seen in the mounting of two of the engines wholly within the wings, where they are surrounded by steel fireproof walls. The third engine, of the high nacelle type, is centrally located above the body of the plane.

The engines selected for use are water-cooled Hispano-Suizas, of foreign make since the designers were of the opinion that no domestic engines of sufficient power were available. The central engine has 18 cylinders, in three banks, and produces 1100 horsepower at 2000 r.p.m. It is fitted with an adjustable metal propeller, three-bladed and with a diameter of over 10 feet. The other two engines are each 12 cylinder, and geared two to one. Each produces 715 horsepower at a crankshaft speed of 2000 r.p.m. They are equipped with four-bladed wooden propellers with diameter of almost 13 feet. A detail which should practically eliminate serious engine trouble is the installation of a separate carburetor for each pair of cylinders. The plane is fueled with four gas tanks, also placed in the wings, and has a total capacity of 500 gallons. Three other tanks hold 48 gallons of oil. A factor which greatly increases the safety of its passengers is the frequent use of steel forgings throughout the ship, and also the utilization of stainless steel rivets on all occasions.

## Trans-Atlantic Air Service

*Condensed from* Aeroplane *(British Weekly), March 23, 1932*

Consent has now been obtained by the Trans-American Air Lines Corporation from all governments concerned, for an air mail route from Detroit to Copenhagen, Denmark. The last consent, that of Iceland, was given by its Parliament on March 19. In that consent they ratified a bill which gave the American corporation the concession for seventy-five years and which also stated that no other American firm would be granted a similar concession until after fifteen years. The route will be from Detroit, over northern Canada, Greenland, across Iceland, the Faroe Islands and the Shetland Islands, to Copenhagen, Denmark.

## Wind Tunnel Tests on Miniature Automobiles

*Condensed from* Automotive Industries, *April 2, 1932*

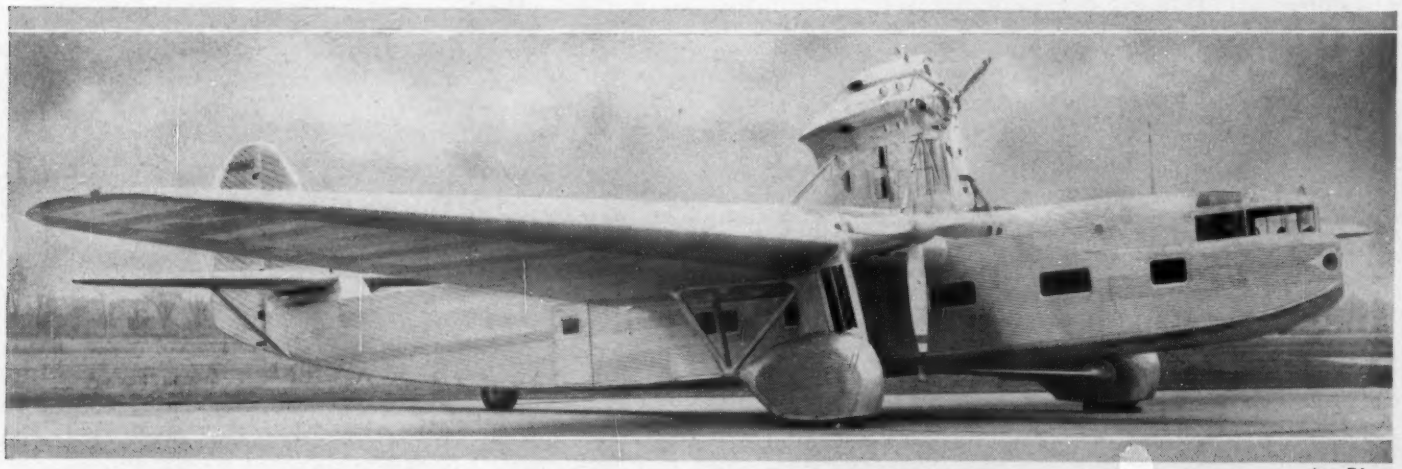
Wind tunnel tests on model automobile bodies of various shapes, recently completed at the University of Michigan, show that streamlining can reduce wind resistance to a small fraction of what it is in present-day cars.

Air resistance at normal automobile speeds is expressed fairly accurately by the equation:

$$R = KAV^2,$$

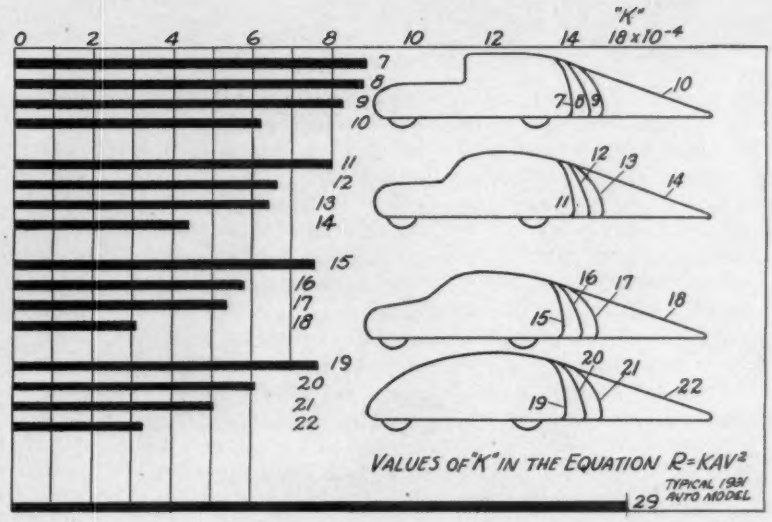
where "$R$" is the air resistance, "$A$" the area of the car projected upon a vertical plane, "$V$" the car's velocity, and "$K$" an experimental coefficient depending on the form of the car. In a passenger automobile the body is essentially a rectangular box. Streamlining such a car means designing a front and a rear section to be added to this box so that it will move with the least possible disturbance of the surrounding air. Accordingly, the model used in the wind tunnel tests was made up of a more or less rectangular section, to which could be fastened any of a number of different front and rear sections, as shown in the first diagram. The model was one-eighth the size of a standard sedan.

To determine the drag of an airfoil or balloon model is comparatively simple; the test of an automobile model, however, is complicated by the necessity of



Aero Digest

***Power and clean lines are combined in the new Ford plane.***




***Streamlining cuts down wind resistance enormously.***

providing a road surface which will travel past the model at a high speed. A running belt mechanism is of no value, for it disturbs the air stream more than the model itself. A fixed plate does not duplicate the conditions under which a car actually operates, for this is analogous to having the road travel along with the car.

Instead, the "aerodynamic reflection" method was employed. Two identical models were placed bottom to bottom, so that a neutral plane of air flow, acting like a road surface, was produced between them. The lower model was supported entirely by guy wires, and only the upper model was tested. Test runs were made at air speeds of from 50 to 90 m.p.h.

The wind tunnel test results were found in terms of "*K*", the drag coefficient, and are given in the first diagram for all of the model shapes used, including a model of a typical 1931 automobile. The rear contour is seen to be more important than the front, but the effectiveness of either may be spoiled by poor design in the other.

The air flow about the models was studied by means of a light steel wand, at the tip of which was attached a short length of silk thread. By placing the end of the wand at any desired point, the direction of the wind at that point could be plotted on cross-section paper. The figures at the bottom of the page are typical diagrams constructed in this way.

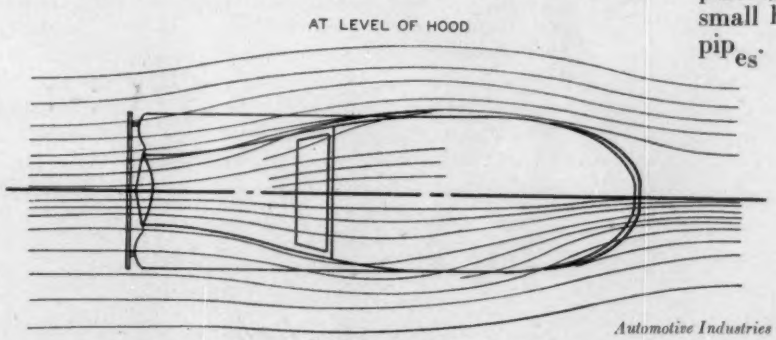
The wind tunnel method is much cheaper and more rapid than the method of testing full-scale models on the road. It furnishes information on pitching moments and tendency to lift off the ground which cannot be gained in any other way. As automobile speeds increase, the wind tunnel is certain to come into more general use.

## Gasoline from Natural Gas

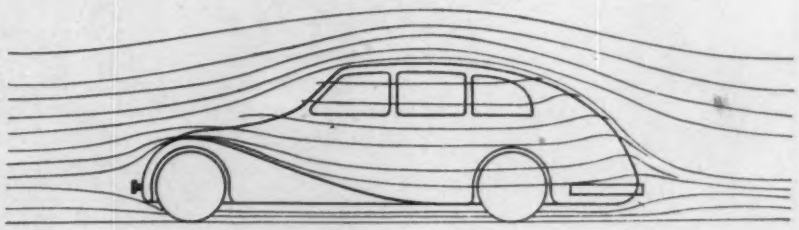
*By* J. A. Campbell

*Condensed from* The Valve World, *March-April, 1932*

To the layman this title may seem a bit paradoxical, because he knows that gasoline is in some way derived from crude oil. To him gas is gas; how can one take a liquid from it? The feat has been accomplished, and use is being made of it today, although the commercial process is somewhat complicated.




*Automotive Industries*



***Air flow diagrams made from wind tunnel tests of model automobiles.***

Natural gas and crude oil are very closely related to each other. Each is a hydrocarbon, having its own ratio of carbon to hydrogen. The gas is the propellant which drives the oil from the earth. Since the gas and oil are in such intimate contact, with temperatures well above that of the atmosphere, the more volatile fractions of oil have a tendency to vaporize and diffuse through the gas in much the same manner that air over a body of water becomes saturated with water vapor. The problem of the natural gas engineer is to separate this natural gasoline from the natural gas and to sell it to refineries, where it is blended with ordinary gasoline to make motor fuel. Today the average blend contains about 25 per cent derived from natural gas.

Gas and oil emerge from a well and are passed through a gas trap which separates the two. The gas is led through pipes, joining with other wells, to the main plant where another separator removes more oil. Any crude oil penetrating beyond this point is very troublesome, because it fouls compressors. The gas is compressed, cooled, and conducted through a series of scrubbers to remove all traces of crude oil, water, and condensate formed by cooling under pressure. The gas is then ready for the absorbers, where gasoline is removed from the natural gas.

These absorbers are large steel shells containing plates, each of which is perforated with thousands of small holes. In these plates are also nine oil overflow pipes. The gas is fed in at the bottom and passes up through the openings. Cold oil is fed from the top and covers the plates. The gas coming through the perforations forms millions of tiny bubbles, called froth. The gasoline passes into the surrounding oil by absorption, and this "fat" oil is led through the overflow pipes to the evaporators, where it is heated, and the gasoline vapor driven off.

# COSMIC RAYS

(*Continued from page 73*)

laboratory; that it comes from outside the earth; that it is not very far from constant in intensity.

However, there are many interesting questions as yet unanswered. For instance, does the radiation consist of a rain of electromagnetic energy corpuscles like light or x-rays, or does it consist of a rain of material particles such as electrons or protons? And if material particles, are they electrically charged or uncharged? Where and how does the radiation originate?

This summer's survey will include extensive measurements of cosmic ray intensities at twenty odd stations on all six continents and in all zones but the antarctic, at altitudes up to eighteen thousand feet above sea level. The measurements will be made with identical apparatus all calibrated against the same standard. Thus for the first time it will be possible to make directly comparable measurements of the cosmic radiation at widely separated points.

Professor Compton will make measurements in Hawaii, Australia, New Zealand (near the south magnetic pole), Peru, Canal Zone, Mexico and Northern Canada (near the north magnetic pole). The Asiatic survey will be conducted by Prof. J. M. Benade of Lahore, India, who will visit Ceylon, Java and points in northern India. Prof. S. M. Naude of Cape Town will conduct the survey in South Africa. Dr. E. O. Wollan of the University of Chicago will visit Spitzbergen, and several European points. Prof. Ralph D. Bennett of Technology, with the coöperation of Prof. J. L. Dunham of Harvard, will conduct an expedition which will make measurements in northern and southern Alaska, as well as in the Sierras of California and the Rocky Mountains in Colorado.

It is hoped that the results of the survey will establish once for all the variation of cosmic ray intensity with latitude, longitude and elevation above the earth's surface. Measurements near both magnetic poles will show its dependence on magnetic latitude. By making continuous observations for several hundred hours at each station, any diurnal variation should be detected.

The indirect results which might be expected from the measurements are these: the variation with altitude will give a measure of the penetration in air, as well as the distribution in energy of the particles comprising the radiation. An increase in intensity near the magnetic poles of the earth would indicate that the rays consist of charged particles. A variation with solar time would indicate that a part of the radiation comes from the sun and its origin should be sought in the fixed stars. A variation with sideral time would indicate a localized source in some particular region of the universe.

# LABOR

(*Continued from page 67*)

justice also includes purely administrative elements. It involves the elemental idea of fair-play.

In a mine with which I am acquainted, the morale is, fortunately, excellent. The following examples of the policy pursued explain why a favorable situation exists. The superintendent of one of the departments, a valuable but excitable man, was angry with a workman over a mistake that he had made. In his excitement he grasped the workman by the arm. The latter misunderstood. A rough-and-tumble fight occurred. The manager of the mine suspended the offending superintendent, and, in spite of the willingness of the workman to drop the incident, insisted on a formal apology.

In another mine, a subordinate department head discharged an engineer who had wrecked an important machine by careless manipulation. In replacing this man, he skipped the brother of the discharged engineer, who was next in line for promotion. It looked as if the executive was punishing the man for the faults of his brother. It appeared certain that this step would create a great deal of resentment. The manager promptly overruled the act of his assistant, risking the loss of a valuable executive member of his staff in so doing. But this sort of fairness should be fundamental in any sound administrative system.

*EDITOR'S NOTE. Mr. Lewisohn will continue his discussion of the relation of the engineer to labor in the October issue. The status of laborer, his desire for the opportunity to better himself, and the necessary attitude of the engineer toward the labor problem are the subjects of the concluding installment.*

# ELECTRONIC

(*Continued from page 72*)

emitted and its energy $E$ is related to the color (*i.e.* frequency) by the very simple equation

$$E = h\nu$$

where $\nu$ is the frequency of the light wave and $h$ is the well-known "Planck's constant." If we give an electron sufficient energy to lift it above the vortex line, it will then, in all probability, leave the atom forever. The atom will now continue its existence for a time with one of its electrons missing. We call this an "ionized atom" or simply a "positive ion" since there will be some unneutralized positive charge. Eventually this ion will meet an electron, take it into its household, and become a normal neutral atom again.

If two atoms come together to form a molecule, we have two "vortices" instead of one and a certain amount of overlapping of influence. If the "hill" between the two atoms becomes very low or else very "thin" then the electrons in the occupied levels run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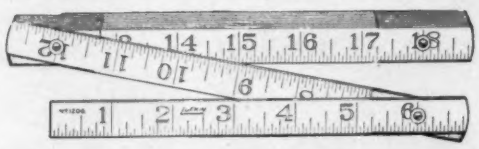

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from one atom to the other rather freely. Although an electron is thus fairly "free" inside the molecule, the "outside" walls are still high.

If we bring many atoms together as in the case of a block of metal, we have what might be called a very large molecule and we can represent conditions very roughly by an extension of our model. Here the atoms are so close together that the "potential hills" between the atoms are almost obliterated so far as the outer electrons of each atom are concerned. These electrons run quite freely throughout the metal and thus make electrical conductivity possible. We notice however that the "outside walls" are still high, thus keeping the electrons inside the block as a whole. That is the "free" electrons in a metal do not jump right out into space *unless we give them energy*. This can be done by *heating* the metal or it can be done by bombarding it with *light quanta* with "$h\nu$" values great enough to lift electrons above the vortex line.

### Thermionic Emission of Electrons

Incidental to his invention of the incandescent lamp, Edison discovered that hot conductors emit negatively charged particles. Although for many years little or no commercial use was made of this "Edison effect," physicists here and abroad carried on important scientific studies which led to an accurate understanding of the emission of electrons from pure metals. These studies lead to the picture of the process of electron emission from heated metals which has been described above. The hot filament rectifier and the three element vacuum tube, now so well known, soon developed as engineering applications of the results of these important researches in physics. Since the engineer is always on the lookout for methods by which specific jobs can be done with the maximum efficiency, the great industrial research laboratories concentrated their efforts on the development of filaments and surfaces which emit the maximum number of electrons per watt input to the heating circuit. The engineer is now far ahead of the physicist. After having been given a little knowledge of the fundamentals, engineers used "cut and try" methods to develop very quickly extraordinarily efficient emitoors of electrons. These results have been obtained using "composite" surfaces, *i.e.*, the thoriated tungsten filaments or the well-known "oxide" coated surfaces. From the standpoint of pure physics, it is still impossible to give a detailed explanation of the observed emission, although considerable progress has been made using modifications of the models discussed here. The engineers have thus opened up a great new field for research and careful exploration. Students in this branch of "electronics" are thus assured in advance that there are important new scientific discoveries to be made. Important new results are being reported in scientific papers every month, but it will probably be years before the subject is completely understood. The modern engineer will therefore study with care and interest the results of these researches in pure physics which it is certain will eventually lead to a complete understanding of the technical practice of the art and will point out the way for the engineers of tomorrow.

### The Photoelectric Effect

The emission of electrons from metals by light is very closely related to thermionic emission. If we give electrons energy by bombarding the metal with light quanta, they can overcome the surface forces and jump right out of the metal. We use the wave theory of light to calculate where light goes but we use the *quantum theory* to tell what light does. We may then think of the interaction between light and matter in terms of a violent bombardment of the metal by minute bullets or quanta. The energy delivered by *each one* is dependent only on the color. The number which strike depends on the *intensity* of the light. Thus we see that if a metal surface is produced with low outside walls so that very small electrical forces hold the electrons in, we can get them out with the minimum energy input. Again the engineers have accomplished wonderful results and have opened for investigation an important field of physics of great interest to the scientific world.


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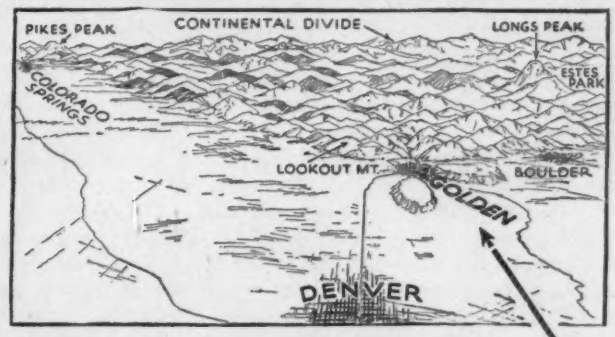


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# LIFE

(*Continued from page 71*)

its union with A. AB joins with C and forms an unstable compound, ABC; but the point of its instability is between A and B. The compound breaks down, liberating A with its capacity for uniting with B, and BC, a new compound. This is a very simple statement of the process called catalysis, and it is the first step toward life.

Picture now a somewhat more complex catalytic process. Particles A B and C unite to form ABC (see Figure 3). This group has now a capacity for taking on another particle of A, then another of B and then a particle of C. The new polymer contains two groups of ABC. If this double group now breaks down it may form two separate groups, each consisting of ABC. Here the group has acted as its own catalyzer and the result is two atomical groups or compounds. In their very simplest form we have seen growth and reproduction in this purely chemical history. Such matter is alive, for it is self-renewing and reproducing. In some such way as this life began; and enormously complex as are the processes of life in cells or men they all reduce, in ultimate analysis, to this story.

It was still a far cry from the cell when these molecules first began to live by adding to themselves and reproducing themselves. We could conceive of the group ABC as being either a single molecule, very complex and unstable, which loses atoms and picks up atoms and tends to renew itself, or which may gather so many atoms that it can break down into two or more molecules like itself. Or we may picture ABC as a complex, unstable colloidal group formed of many molecules cohering and exchanging atoms between one another as well as uniting with atoms from the surrounding media. In either case a self-renewing and reproducing creature is the result.

There are at least three candidates among the chemical elements for the honor of originating life and maintaining the march of evolution — sulphur, silicon, and carbon. Each is capable of forming great numbers of compounds with other elements. Each forms unstable compounds which are sensitive to their environment and which tend to change — losing some atoms and picking up others, or breaking down into minor groups of atoms as the environment changes. It would be curious to wonder what the living world would have been like if silicon had been the successful competitor instead of carbon. We geologists never cease from being amazed at the extraordinary and subtle sequences of change through which the molecules of our minerals pass — but they are never self-renewing or reproducing. We may wonder what the psychology of a sulphur-man might have been, even while our carbon compound brains give our psychologists trouble enough. Carbon alone found the way to form the self-catalyzing, self-renewing and reproducing compounds.

Once the process began there was no limit to the complexity to which the compounds could attain.

Beyond this physical complexity, new intricacies began to evolve, when groups of interacting particles arranged themselves into structures within the living unit, and performed special functions which a single particle had performed in the simpler body. Greater refinement of function and the separation of new functions lead toward the structure of the cell. I have sketched, in Figure 1, a very hypothetical picture — no more than a suggestion — of how these changes may come about. If you feel interested in the cell, read a slender little book called the "Physical Basis of Life" by that exquisite writer, scholar and scientist, Edmund B. Wilson.

We have now crossed the gap from sun to cell — partly upon a bridge of solid fact and of weighed and tried inference, partly on very tenuous threads of hypothesis. We are sure that the earth came from the sun, although, if the passing star sidewiped the sun it is not wholly impossible that the earth contains part of that vanished assailant as well as part of our familiar sun. We are sure that the earth originally had a great inheritance of the sun's heat. But we're still in doubt whether the earth spent its effective heat as the moon has done, and now feeds its volcanoes with heat of its own manufacture derived from radio-active elements — or whether the earth still retains much of its patrimony of solar heat. It is certain, though, that all the heat that helped to generate life and that helps now to maintain life came from the sun and still comes. We who live are thus doubly the children of the Sun; for first, our very atoms came flaming out of the Sun and later when the Earth's surface was cold, the genial sunlight helped to kindle molecules into life, and helps still to retain them alive.

It took a long time to prepare the birthplace of life by flinging the earth out of the sun and reorganizing it into a cool, moist planet. It took a long time for the complex self-catalyzing carbon compounds to form that which could be called the first true seeds of life. It took a tremendously long time for these first living particles to develop into the unbelievable complexity of a single cell. And it has taken at the least fifteen hundred million years for simple cells to evolve into the complex plants and animals of today, including you and me. Yet we who write and read this essay lived with the first moleculobiont as surely as we burned in the sun. We must grant that those early periods bridging the gap between Sun and Cell were long — perhaps of the order of magnitude of all the time that stretches between the cell and this present day, when your brain, that contains about six billion cells, reads this magazine and thinks long thoughts on the tremendous ages that lie behind us.

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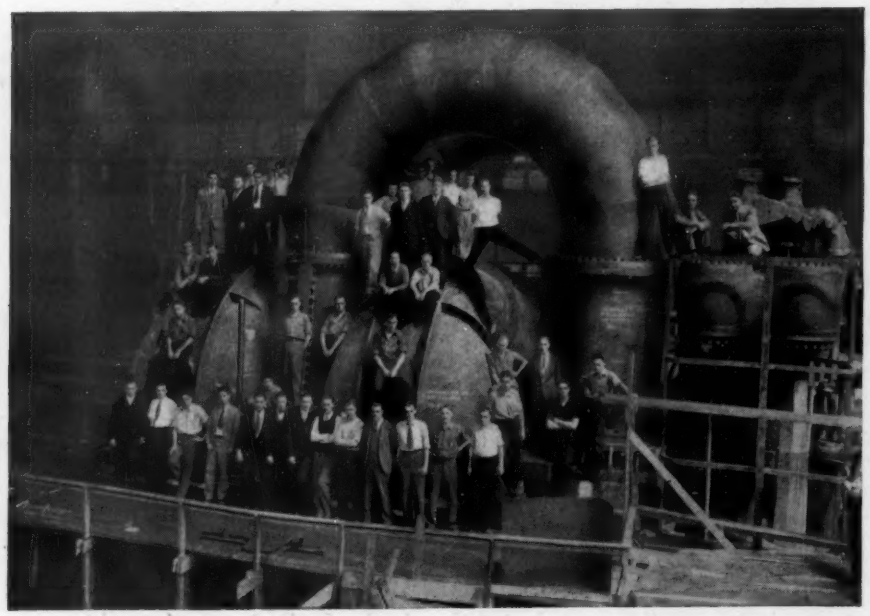

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